DOCUMENT RESUME

ED 398 066 SE 058 721

AUTHOR Masingila, Joanna O.; King, K. Jamie
TITLE Middle School Students' Use of Function Ideas in Everyday Mathematics.
PUB DATE Apr 96
NOTE 16p.; Paper presented at the Annual Meeting of the American Educational Research Association (New York, NY, April, 1996).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Elementary School Students; *Functions (Mathematics); Intermediate Grades; Junior High Schools; Junior High School Students; *Mathematical Applications; Middle Schools; Observation
IDENTIFIERS *Connections (Mathematics); *Middle School Students

ABSTRACT

This paper describes preliminary analyses of data from an ongoing project entitled "Connecting In-School and Out-of-School Mathematics Practice." During this project the authors are: (1) investigating how middle school students use mathematics concepts and processes in a variety of out-of-school situations, and (2) working with middle school teachers to develop curriculum ideas to facilitate connection-making by students and investigating whether students are connecting their in-school and out-of-school mathematics learning and practice. The majority of the paper discusses the observations of middle school students (n=6) using function ideas in their everyday activities. Analysis of data showed that students used functions ideas in many situations. (MKR)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

PERMISSION TO REPRODUCE AND
DISSEMINATE THIS MATERIAL
HAS BEEN GRANTED BY
JO. Masingila

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC)

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)

This document has been reproduced as received from the person or organization originating it.

Minor changes have been made to improve reproduction quality.

Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

ED 398 066

Middle School Students' Use of Function Ideas in Everyday Mathematics

Joanna O. Masingila
K. Jamie King

Syracuse University

Department of Mathematics
215 Carnegie
Syracuse, NY 13244-1150
jomasing@sued.syr.edu
kjking@mailbox.syr.edu
315-443-1471

Paper presented at the Annual Meeting of the American Educational Research Association, New York, April 1996.

BEST COPY AVAILABLE

Middle School Students' Use of Function Ideas in Everyday Mathematics

Joanna O. Masingila and K. Jamie King

Syracuse University

Introduction

Research on cognition and learning has pointed out the need for closing the gap between learning and doing mathematics in and out of school (e.g., Masingila, 1992; Saxe, 1991a). Furthermore, recent proposals for teaching and learning mathematics in school have encouraged educators to connect mathematics with other subjects and out-of-school mathematics practice. For example, the following challenges are laid out in the *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics (NCTM), 1989).

> Problem situations that establish the need for new ideas and motivate students should serve as the context for mathematics in grades 5-8. Although a specific idea might be forgotten, the context in which it is learned can be remembered and the idea re-created. In developing the problem situations, teachers should emphasize the application of mathematics to real-world problems as well as to other settings relevant to middle school students. (p. 66)

> The intent of this standard [Mathematical Connections] is to help students broaden their perspective, to view mathematics as an integrated whole rather than as an isolated set of topics, and to acknowledge its relevance and usefulness both in and out of school. . . . If students are to become mathematically powerful, they must be flexible enough to approach situations in a variety of ways and recognize the relationships among different points of view. (p. 84)

However, in order for teachers to help students make these connections we need to know how students use and perceive how they use mathematics in out-of-school settings. This is

relatively unexplored territory, as Pea (1991) noted: "Even though that field [mathematics education] calls for relevance of mathematics learned to everyday settings, there has been remarkably little ethnographic investigation of mathematical activities by children in settings outside classrooms" (p. 490).

Structure and Aim of the Study

This paper describes preliminary analyses of data from an ongoing National Science Foundation-funded project, entitled, *Connecting In-School and Out-of-School Mathematics Practice*.[1] During this project we are (a) investigating how middle school students use mathematics concepts and processes in a variety of out-of-school situations, and (b) working with several middle school teachers to develop curriculum ideas to facilitate connection making by students and investigate whether students are connecting their in-school and out-of-school mathematics learning and practice.

We believe the Mathematical Connections standard in the *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) may be the most difficult for teachers to bring to life because it requires teachers to have an integrated view of mathematics themselves and knowledge about contexts that may be relevant mathematically for their students. By gaining some knowledge about students' mathematics learning and practice out of school, we will be able to work with the teachers to identify ways that they can facilitate connection making and enabling students to build on out-of-school knowledge in school and vice versa.

This paper describes preliminary analyses of our observations of middle school students using mathematical concepts and processes in a variety of out-of-school contexts. The majority of the paper will be devoted to discussing how we observed students using function ideas in their everyday activities.

---

[1] The research described in this paper was funded by a National Science Foundation-sponsored grant (RED-9550147) awarded to the first author under the Faculty Early CAREER Development Program. The opinions expressed in this paper are the authors' and not necessarily those of the National Science Foundation.

Data Sources and Methods

In June 1995, we visited one of the middle school teachers with whom we will be working later in the project and discussed the project and asked for volunteers. Six students (five females—Kristen, Robin, Amy, Jessica and Nicole, one male—Linus) returned the permission forms and volunteered for the project. We met with all the students and their parents before data collection began to explain in person the purposes and procedures of the project.

Throughout the summer and fall of 1995 we collected data on their mathematics practice out of school through (a) activity sampling with electronic pagers and logs, (b) observations of each student in a number of out-of-school activities, (c) interviews with students about logs and observations, (d) logs kept by students and parents, and (e) interviews with students and parents about logs and their activity.

We met with the respondents prior to the activity sampling and explained the procedures. The students carried electronic pagers for one week and completed a sampling form whenever they were signaled. This method has been used by other researchers with success (e.g., Schiefele & Csikszentmihalyi, 1995). Each respondent received seven to nine signals per day. The sampling form consisted of several open-ended items: (1) Describe what you are doing (for example—mixing lemonade).; (2) Are other people involved in what you are doing? If so, describe who they are (for example—brother).; (3) List any objects or tools that you are using (for example—pitcher, measuring cup, lemonade mix, water, ice).

We met with the respondents following the activity sampling for debriefing and to collect the pagers and sampling forms. We also discussed what kind of activities the students would be doing in the coming weeks. We analyzed the sampling forms and, using this information and the information about their activities that we obtained through our conversation with the respondents, we selected several activities in which to observe the students.

Later in the summer, we also asked each respondent to keep a log of how they used mathematics. The log consisted of pages for four days, and the respondents were asked to "Describe how, where, and in what activities you used mathematics today." for all four days. In

the fall we asked each respondent and a parent to keep a log for four days. The directions were the same as described above and the students and parents each recorded descriptions about their own activities.

Every time data were collected—through the sampling form, the log pages, field observations—we met afterward with the respondents to discuss what they had written and to ask questions that we had. During the interviews that followed the student/parent log-keeping, we interviewed the student and parent together. In this way, the two of them functioned as a focus pair during the interview and both were able to reflect on each other's mathematics practice.

We are presently finishing up the transcription of audio tapes and video tapes and beginning to analyze the data using a software package for qualitative data analysis. We are analyzing the data through a process of inductive data analysis using two subprocesses that Lincoln and Guba (1985) called unitizing and categorizing. Unitizing is a process whereby "raw data are systematically transformed and aggregated into units which permit precise description of relevant content characteristics" (Holsti, 1969, p. 94). Once the data have been unitized, units can be compared with other units and like units can be grouped together into categories. Categories can then be compared to other categories to establish relationships among them.

Mathematical Concepts and Processes: Evidence of Function Ideas

In our preliminary analyses, we have observed a number of areas of mathematical concepts that we have tentatively categorized as geometry, function (including the concept of variable), measurement, arithmetic (including computational algorithms), and probability. We have also observed mathematical processes that we have tentatively categorized as visualizing, managing time, decision making, measuring, estimating, budgeting, modeling (including problem solving). This paper will focus on the ideas of function that we observed in the students' activities.

The concept of function—and closely linked to that, the concept of variable—is a prevalent mathematical idea in the world. There is a large body of research concerning functions and how the concept of function can be thought of and used in different ways (e.g., as a causal relation, as co-variation). In our observations reported in this paper, we saw function ideas being used a

causal relationships, that is, variables represent quantities that change and functions describe relations between phenomena. We observed our respondents using function ideas in a variety of situations. At this time, we have grouped these instances according to the type of actions the students were engaged in, as classified by our observations. These activities are planning, working, creating, investigating, and playing. We will discuss the first four of these briefly and then discuss the last one in greater detail.

We observed the students using function ideas in (a) planning when they scheduled activities and when they made decisions about preparing a meal, (b) working when they did chores (e.g., mowing the lawn), (c) creating when they made boondoggle and other craft items and when they created music, and (d) investigating when they tried to determine the salinity of sea water, the weight of certain coins, and how what they saw changed according to the lenses used by the optometrist.

It is important to note that it is our perception that the students are using function ideas during these activities; the students were not always aware of this. However, they seemed to always understand that there was a relation between variables in a situation and used their own language to describe this relation. For example, Linus described the relation between the gas consumption of his lawn mower and the amount of time he spent mowing.

Linus: (pause) I have to fill the gas tank and I sort of have to know how long a tank will last.

Researcher: How do you know how much to fill?

Linus: Well, since I know about how long it will last, I just watch the time and when it gets close I just look in the tank to see if it's full and if it isn't, I fill it.

Researcher: Do you know how much gas fits in the tank?

Linus: No, because it doesn't matter; I just fill it up. (linus.beep.int, 1995, p. 2)

Linus understood that the amount of gas that is used by the lawn mower depends upon how long he runs the mower. He also appears to measure the amount of gas the tank will hold not by a capacity quantity, but by a time quantity.

Function Ideas in Play

As one might expect from middle school students, our respondents spend quite a bit of time playing in their everyday activities. Some of their playing took place in activities that were organized and supervised by adults. We observed the students using function ideas while playing in organized situations at soccer camp, at ice hockey practice and games, at volleyball practice, at swimming practice, and on a ropes course at a summer camp. Other playing occurred in activities that were not organized and supervised by adults, but rather were controlled by the respondents themselves; we have termed this recreational play. We observed the students using function ideas in recreational play while miniature golfing, playing basketball, in-line skating, golfing, downhill skiing, diving, water skiing, and using a remote controlled boat.

Function ideas in organized play. A common relation we found in many of the play activities involved the use of angles. In general, the relation was that the angle that was to be used to accomplish something depended upon another variable or several variables.

In soccer, we observed that the angle at which Kristen kicked the ball depended upon the location of her teammate to whom she was kicking the ball and also the location of nearby defensive players. When shooting on goal, the angle she used depended upon the location of the goalie and also her own location in relation to the goal.

When Kristen did not have the ball on offense, she tried to keep herself at a "good" angle to her teammate with the ball so that she was in a position to receive a pass from her. The following comment from our field notes from observing Kristen at soccer camp discusses a situation involving this idea.

> The coaches had three campers demonstrate an angle pass (two offense, one defense) and later three different campers demonstrate an overlap. The angle pass demonstration involved one player with the ball being guarded by a defender. The player without the ball was to run to a "good" position to receive an angle pass and then shoot on goal.
> (kristen.soccer.obs, 1995, p. 2)

Thus, the location of her teammates and the opposing team members determined the angle at which Kristen positioned herself. The players seemed to be learning through experience what constituted a "good" angle—in other words, an angle at which there was a high probability that they could receive a pass from their teammate. We observed the coaches talk about angles on defense as well.

> The coach had the girls sit down and then talked about some ideas and strategies for the upcoming game they would have. She discussed terms such as: . . . angle of approach, defensive angle . . . . (kristen.soccer.obs., 1995, p. 3)

When playing defense, the angle Kristen used for trying to tackle a player with the ball depended upon the speed of the opponent and the opponent's location on the field.

Kristen also played volleyball. Sally (Kristen's mother), in an interview after the log keeping, discussed watching Kristen play volleyball and noted that the angle at which Kristen hit the ball determined what happened.

> Sally: . . . the angle at which she hits the ball affects which way the ball rebounds—like when she spikes it or uses a power hit. I think the way she shapes her hand when she hits also makes a difference. (kristen.log&mom.int, 1995, p. 2)

Whereas Kristen's mother noted that the angle Kristen used determined what the ball did, we observed that what Kristen wanted to accomplish determined the angle she used. For example, the location of the opponents on the court influenced the angle Kristen used to hit the ball—whether she tried to spike the ball in an undefended area or hit the ball past the outstretched hands of blockers.

When observing Amy during swimming practice, we noted the swimmers using very flat dives when practicing sprints. We observed that if a swimmer wants to start fast, then she should not dive very deep into the water; this means that she should dive at an angle that is approaching a straight angle. Thus, the depth that the swimmer wants to go influences the angle at which she will position her body upon entry.

In many of the observations that involved our respondents in organized play, the adults in charge of directing the play engaged the participants in thinking about angles because they sometimes talked about and demonstrated what angles the players should use in different situations.

Function ideas in recreational play. In the recreational play situations we found the respondents also used angles in discussing functional relations. In one of our observations, Kristen, Robin and Jessica were playing miniature golf together. In the interview after the game, the girls discussed using the wooden blocks and walls in the course to bank the ball into the hole.

Researcher: So ricochet, or bank, or hit it off the wall—how does that help you?

Kristen: 'Cause you go farther without having to bump into a block.

Researcher: Without having to hit twice?

Kristen: Yeah, like the thing (block) might be at an angle but the ball will go right by it if you hit it at an angle; it will bounce off the wall and go into the hole.

Researcher: Do you think that changes how fast the ball goes?

Kristen: No, it doesn't.

Robin: I think it does! Because it's going with force at one speed then it hits the thing (wall) . . .

Researcher: The wall slows it down . . . ?

Robin: It, like, absorbs some of the speed. (putt-putt.int, 1995, p. 2)

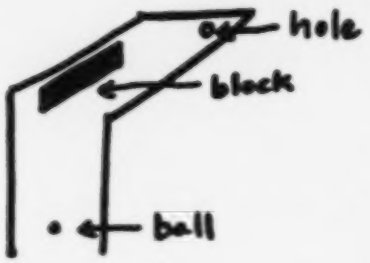
The girls also discussed how the location in which they wanted the ball to end up, and the obstacles that were in the way, determined the angle at which they hit the ball with the putter.

Robin: Well, it depends on how you want to angle it.

Kristen: It depends on how you gotta hit it. If the hole is over here and you have to get by the bend, then you have to hit it off the wall so it will go in the direction of the hole (see diagram below).

Robin: But if you angle the putter this way, the ball will go toward the hole without bouncing off of anything.

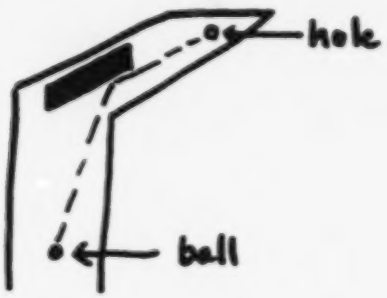
Researcher: What if you decided to bank it, or ricochet it? What if there was a block here, then . . . (see diagram below)



Jessica: You'd want to hit it off the block...

Kristen: Well, you'd want to hit it on the block near the edge so. . . actually you'd want to hit it over here so it would ricochet here . . . (see diagram below).

(putt-putt.int, 1995, pp. 2-3)



The girls understood that the path of the ball depended upon the angle at which it hit an obstacle (wall or block). They tried to have the ball hit the wall or the block at a particular angle so the path of the ball after it hit the obstacle would take the ball closer to the hole. Thus, the function ideas we observed at use in the miniature golf context were that the rebound path of the ball was a function of the angle at which it hit an obstacle and the angle of their putt was a function of the location of the obstacles and the hole.

Another activity in our recreational play category is skiing. Linus and his mother, Marjory, talked about skiing in their logs and also in our interview with them about the logs. Marjory noted in her log that she did not think she used any mathematics in skiing.

M's log: [In] skiing I don't use math and I rarely have to solve any problems; it just comes naturally—I've been skiing for so long!

Researcher: (referring to log) About skiing then, you don't see any problem solving? When it comes naturally you mean when you come down the hill and . . .

Marjory: How much I have to curve, how much I have to brake down before I do the curve and how fast I can go to still control my skis.

Researcher: About turning, what kinds of movements do you have to use?

Marjory: See I don't know, it just does it.

Researcher: Picture yourself going down the hill and you've come off the chair and you know you're not going to go straight down. What do you do with your body to turn?

Marjory: I shift my weight and I lean. That's what I meant. I definitely do mathematical things there but I don't do it with my mind because I have been doing it for so long I don't have to think at all.

Researcher: . . . what do you have to do to go down the hill faster?

Marjory: Just go straight.

Researcher: But how do you decide what's too fast and then what do you do?

Marjory: If I get scared—if I don't feel comfortable any more—then I start turning more.

Researcher: Shift your weight?

Marjory: And if I want to go fast, or if the hill is not very steep, I go straighter. If it gets steeper and I go faster, I turn more sideways. So from going down straight to going down in ninety degree angles—that's how I adjust my speed. That slows me down. (linus.log&mom.int, 1995, pp. 1-2)

Marjory describes the angle at which she skis as a function of the speed she would like to go. Later in the interview Linus talked what he had written in his log about skiing.

L's log: When I went skiing I had to measure in my head the angle of the slope so that I could estimate the speed and when I had to turn.

Researcher: Talk with me about the skiing.

Linus: Skiing is fun.

Researcher: How did you measure in your head the angle of the slope?

Linus: How many times I want to turn.

Researcher: So you face this big hill, and do you decide right away, "I'm going to take about five turns here"?

Linus: No, I just go straight down.

Researcher: Until when?

Linus: Maybe about eighty or ninety! (referring to going 80 or 90 mph)

Researcher: Well, fast. How do you know you're going eighty or ninety?

Linus: I have this system where I see how fast it takes me to get from one tree to another. (linus.log&mom.int, 1995, pp. 10-11)

Linus' system was to go straight down until he wanted to slow down; at that point, he would begin skiing at an angle. Thus, the angle at which he skied was determined by his desired speed. Linus also compared his skiing to his parents' skiing and noted that his parents chose not to go straight down the slopes.

Linus talked with us in another interview about playing with his remote-controlled boat. He described how the angle at which he turns the control is dependent upon the speed of the boat.

Linus: . . . I try full throttle spins.

Researcher: What do you mean by that?

Linus: Like, I want the boat to be going fast and straight for awhile and I turn it sharp and it spins around and comes back or it does a loop and keeps going.

Researcher: How do you do that with the controls?

Linus: I turn this wheel (demonstrates with the remote) and if I turn it too far I might flip the boat so I have to know just how much to turn it so I get a good radius.

Researcher: What do you mean?

Linus: Like, I want the boat to turn with a certain radius so I have to test out a few turns to see how much the wheel affects the turn. I know it will flip if it's at full throttle and I turn it all the way so I try a little less [more] each time. (linus.beep.int., 1995, pp. 5-6)

Summary and Next Steps

Although we have only made preliminary analyses of our data, we see students using function ideas in many situations. So far, we have only observed them using functions as causal relations—the angle of a soccer kick and the angle of body position were functions of the location of other players, the angle of defensive position was a function of the speed and location of opposing players, the angle of the hand in a volleyball hit was a function of where the player wanted the ball to go, the angle of a dive was a function of the desired depth, the rebound path of a miniature golf ball was a function of the angle at which it hit an obstacle, the angle of the putt was a function of the location of obstacles and the hole, the angle at which a person skied was a function of the desired speed, the angle at which a control was turned was a function of the speed of a boat.

The examples above are just a few, out of a wealth of data, that illustrate how we saw our respondents using function ideas in their everyday activities. We see some rich situations that are relevant to these students and for which they have some understandings about the function relations involved. We are continuing to analyze the data we have to try to understand how students are making sense of phenomena they encounter in their out-of-school activities.

Using ideas found through the data analysis of the respondents' out-of-school mathematics practice, we will work with a middle school teacher to develop ideas to help create a classroom practice that has some characteristics of the students' out-of-school mathematics practice. As

Saxe (1991b) noted: "Teachers can engineer a classroom practice that has properties of the daily practices involving mathematics in which many children show sustained engagement" (p. 18).

Saxe (1991b) has discussed characteristics that appeared to promote learning in everyday practices that he thinks can be useful in developing a classroom practice: (a) "mathematics was not a target of instruction; (b) mathematics learning served the accomplishment of pragmatic objectives; (c) artifacts shaped the form of emergent mathematical problems; (d) emergent problems displayed a range of complexity levels; (e) individuals played an active role in problem formation; (f) the solutions of mathematical problems were valued for their coherence, not for the correct use of rigidly prescribed procedures" (pp. 18-19).

Saxe has made use of these characteristics in "constructing a practice consisting of a thematic board game in which children assume the roles of treasure hunters in search of gold doubloons" (1991b, p. 20). By observing the children participate in the game, Saxe and his colleagues have been able to analyze the emergent goals, the form-function shifts, and the interplay among various cognitive forms.

We will draw on Saxe's (1991b) work in constructing a classroom practice in our work in the middle school classroom. We will identify several contexts, by using the collected and analyzed data, that are familiar to students and develop activities that are consistent with the characteristics of everyday practice (Saxe, 1991b) and these will be used to construct a classroom practice. By starting from contexts that are relevant to middle school students and for which they have some mathematical understandings, we hope to help students connect their in-school and out-of-school mathematics practice.

References

Holsti, O. R. (1969). *Content analysis for the social sciences and humanities*. Reading, MA: Addison-Wesley Publishing Company.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage Publications, Inc.

Masingila, J. O. (1992). *Mathematics practice and apprenticeship in carpet laying: Suggestions for mathematics education*. Unpublished doctoral dissertation, Indiana University, Bloomington.

National Council of Teachers of Mathematics (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Pea, R. D. (1991). Inspecting everyday mathematics: Reexamining culture-cognition relations. *Educational Studies in Mathematics, 22*, 481-490.

Saxe, G. B. (1991a). *Culture and cognitive development: Studies in mathematical understanding*. Hillsdale, NJ: Lawrence Erlbaum.

Saxe, G. B. (1991b). *From the field to the classroom: Studies in mathematical understanding*. Paper presented at the RAC/SIG-RME Research Presession of the Annual Meeting of the National Council of Teachers of Mathematics, New Orleans, Louisiana.

Schiefele, U., & Csikszentmihalyi, M. (1995). Motivation and ability as factors in mathematics experience and achievement. *Journal for Research in Mathematics Education, 26* (2), 163-181.